87-268

ORIGINAL FILE

ADVANCED TELEVISION RESEARCH PROGRAM

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

ROOM E15-387, CAMBRIDGE, MASSACHUSETTS 02139 swfs40

August 2, 1988

Chairman Dennis R. Patrick
Federal Communications Commission
1919 M Street NW
Washington DC 20554

RE: Open-Architecture Receiver

Dear Chairman Patrick:

Comments on the Interim Report of the Advisory Committee on Advanced Television Service were submitted by a number of interested parties. In the comments by the Electronic Industries Association (EIA), North American Philips, Sarnoff Laboratories, Matsushita Electric Corporation of America, Cox Enterprises, and Tribune Broadcasting, generally negative statements were made regarding the Open-Architecture Receiver (OAR). Zenith, one of the sponsors of the Advanced Television Research Program (ATRP) at MIT, simply stated that the concept was premature.

Since I coined the term OAR (but not the concept of a 'smart' receiver) and since I was specifically named as the "the most ardent supporter of open architecture" by EIA, it is appropriate that I reply to these comments. The technical statements made in this letter are presented in my capacity as director of ATRP. The opinions and nontechnical statements are entirely my own, and are not to be attributed to MIT or to the ATRP sponsors.

As many of the adverse comments relate to the supposed high cost of the OAR, I would like to point out that in addition to my long experience in designing practical imaging systems that have gone into production, a substantial portion of my present income is from industrial consulting. My specialty is low-cost design in the field of electro-optical and computer-based imaging systems. I am particularly proud of the development of the *Autokon* electronic process camera, a laser-based imaging system that has been sold in Japan for more than ten years without the appearance of cost-effective competition.

12

Telephone 617-253-2579 • Telex 92-1473 • TWX 710-320-0058 • Cable MIT CAM • Telecopier 617-253-8000

****

Executive Summary

• All ATV receivers will have to accept at least two standards - NTSC and ATV - regardless of FCC standards decisions. The best and cheapest way to do this is by scan converting all formats to the parameters of a fixed, high-rate display. Once this price has been paid, the extra cost of the bus-structured configuration of the OAR is very small, and will not materially increase the price of receivers. "Open architecture" simply means that bus specifications are uniform and public so that third parties can provide software or hardware modules for enhanced functionality. Such a design allows the receiver to be upgraded and adapted over time to accomodate itself to evolutionary improvements. This scheme permits an early start to ATV service, without premature standards decisions that are most likely to be a good deal less than optimum. It also eases the conflict between the desire of terrestrial broadcasters for a single standard and the desire of alternative-media providers to have either no standard at all or a self-chosen one for highest picture quality in each medium.

• The OAR concept is described in some detail in this letter, since it has been mischaracterized by many critics. The arguments against the OAR are also considered in detail. Only cost is a potentially legitimate issue. Given the two-standard minimum, I believe that the extra cost will be very small. The manufacturer's development costs for an entire line of receivers may well be less, and a lively market in third-party products, mainly produced in the US, may be expected. The OAR is entirely suitable for use in the home, facilitating connection to many other products and services likely to be used in the home in the future. With the OAR, both consumer and manufacturer can invest with confidence that their investment will not soon be made obsolete.

• A number of the comments argue for a fixed single-standard receiver rather one that can deal with several standards and that is flexible enough to be adapted to evolutionary improvements over time. The commodity-type fixed-standard TV receiver put most American-owned TV receiver manufacturers out of business. While one would certainly not advocate complexity for its own sake, this predilection for a very simple receiver may prove self-destructive. It should be borne in mind that HDTV is not primarily about beautiful pictures. It is about the economy. The most important economic effects relate to the total value added *in the US*, to ATV receivers. For this reason, we should examine the views of foreign-owned companies with particular care. In this connection, it should be noted that there is not a single US-owned company in the Consumer Electronics Group of EIA.

****

The OAR Concept

Many of the comments are off the mark because they attack silly proposals that no one has made, and that no knowledgeable person would make. In particular, no one would advocate a receiver that could cope with all conceivable ATV formats - the EIA "inclusive" concept. No one has advocated legislating the design of receivers, and in particular forbidding the inclusion of decoders in display modules, the EIA "non-inclusive"approach. My idea of the OAR is described in the attached note of June 12, 1988. It calls for a bus-structured programmable design, rather than the "functional integration" usually used at present, in which the receiver is a fixed, stand-alone unit, capable of receiving one permanently fixed format only.

The term "open architecture" means that the system is designed in such a way that third parties can sell hardware and software that can be used with the system to enhance its performance. Hardware additions plug into a bus, and there are no set-top converter boxes. Of course, the original manufacturer can also provide these enhancements, making it easy to sell a full range of products at a full range of prices without redesign. Open architecture is largely responsible for the success of the IBM PC. Apple switched from a closed to an open archictecture in the Mac II, presumably to obtain a similar benefit.

The principal advantages of open architecture for TV receivers are the ability to be *inexpensively* adapted to a range of transmission formats and to achieve improved image quality over time as it becomes economical to utilize available headroom in the system. The OAR can be readily interfaced with a wide range of other units, including VCR's, cable, fiber, DBS, optical disks, computers, video games, cameras, interactive systems, electronic still photographic equipment, people meters, encryption systems, etc. It makes these other devices simpler, not more complex, because of the cleaner and more completely specified interface.

Cost of the OAR

Everyone is properly concerned about receiver cost, since the receivers represent most of the aggregate cost of a new television system. If a single worldwide ATV standard could be agreed upon, a fixed receiver would be somewhat cheaper. A single standard for receivers, however, is inconceivable. At the very least, NTSC will be with us a long time, so that all ATV receivers will have to deal with at least two standards with widely different scanning rates. The *cheapest* way to deal with multiple standards is to use a single display standard (which need not be the same on all receivers) and to upconvert all formats to that display standard in low-level digital signal processing hardware. This is precisely what is done in NHK's MUSE receiver, which also uses a microprocessor for automatic channel equalization.

The principal cost of a receiver is the picture tube and associated mechanical and electrical components. Signal processing, which is the innovative area of the OAR, represents a very small portion of the cost of today's receivers. For this reason, even if the bus structure increased the cost of signal processing by a small amount, it would not materially increase the cost of the entire receiver. Because of the advantages of this design approach, it is being advocated for such diverse low-cost applications as residential electronic systems ("smart house") and automobile control systems.

Relationship to Multiple or Evolving Standards

The OAR is not a dodge to avoid setting transmission standards. To the extent that it is connected with the standards issue, it recognizes that, on the one hand, we are far from ready to set terrestrial standards, and, on the other hand, many entities are preparing to start activities in alternative media rather soon. Many of these proposals will no doubt fall by the wayside, but there is some possibility that several of them will go forward, putting on the market a variety of receivers that are mutually incompatible. This would greatly slow down the proliferation of ATV, and along with it, its potential economic stimulus. In my opinion, it is entirely unreasonable to subject the public to this risk, when it could be avoided by appropriate legislation. Following the precedent of the All-Channel Receiver Law, which is responsible for the viability of UHF, we could require all ATV receivers to be *capable of being adapted to* a reasonable range of transmission formats. As I said above, this would not materially increase the cost of receivers that already had to deal with both NTSC and any one form of ATV. Authority for rule-making could be given to the FCC, which would do this in accordance with its usual procedures of consultation with interested parties. Such a law would level the playing field for all parties and would ensure that both industry and consumers could invest in ATV at an early date with confidence that these investments would not be lost because of subsequent changes in transmission formats.

I believe that terrestrial transmission standards should be set as soon as this can be done with confidence. However, there are many valid issues that simply cannot be resolved in the very near future. One is the fundamental question of whether there is any way at all to achieve substantially higher picture quality *in the home under normal transmission conditions* without impacting the quality on existing receivers. In addition, alternative-media entrepreneurs all want each medium to be allowed to develop to the maximum extent possible according to its own capabilities, raising the important issue of compatibility across different media. In the face of these serious problems, an early decision would be based on guesswork and would likely be wrong. If we want ATV soon without such risks, the OAR offers a way to do this.

Suitability of Open Architecture in the Home

There already are more than ten million personal computers in American homes using open architecture. These computers use all of the different kinds of circuitry found in normal TV receivers, including high voltage, digital interfaces, and low-level analog signals, and that would be required in the OAR. Most users do not get into the more sophisticated problems that are the territory of the computer buffs, but use them in a simple way. When they cannot cope with some special problem, they get the help of a serviceman. The problems encountered are no more confusing than programming most VCR's, which many viewers simply do not choose to do, but use the VCR for playback only. Likewise, many users of the OAR would not make complicated connections to multiple peripherals, but would simply watch TV programs. Two or three times in the life of the receiver they might be called upon to plug in a new hardware module, and if they did not want to do that themselves, they would call a serviceman. That would be a lot cheaper than buying a new receiver. Many changes in transmission format (such as the variable frame rate in the MIT-CC system) would be effected by codes

embedded in the signals and would call for no action on the part of the viewer.

The Relationship to Multiport Receivers

As pointed out in the attached memo, the OAR would use only three ports for all conceivable input signals - rf, analog baseband (3 wires), and digital. The provision of "ports" for different formats is a simplistic approach that can only be used in a very restricted range of applications, namely those that involve two formats that use the same scanning standards. One such case, and it is a very important one, is the proposal to provide for baseband analog inputs to TV receivers. The argument for baseband inputs on NTSC receivers is so strong that I think legislation is warranted here as well. The cost of such input terminals, although small, is signficant in a highly competitive market. The greatly improved picture quality that can be obtained when VCR's are connected in this manner is not made available to users today simply because manufacturers who provide it are at a competitive disadvantage compared with those who do not. A legal requirement to provide such an input removes the competitive roadblock. VCR manufacturers likewise may not provide baseband outputs until there are many receivers that can use them - a classical "chicken and egg" problem.

Additional ports will not solve the problem of interfacing systems with different scanning standards. Scan conversion is required in this case, and in ATV receivers it will be used to accomodate NTSC. It is much cheaper to provide a programmable scan converter (up-converter) than to provide separate ports and special fixed up-converters for each additional format.

****

EIA Comments

These comments were considerably more detailed than the others and also differed in tone, so I shall deal with them separately.

"Open Architecture will Delay ATV Introduction" On the contrary, OA permits manufacturers to sell and users to buy ATV receivers with confidence that they will not be made obsolete by some new standard. It reduces uncertainties rather than increases them.

"Open Architecture Reduces Production Economies ... A single standard receiver could be flexible and adaptable to future developments." I am composing this letter on an open-architecture IBM PC/XT that cost $4000 when it was introduced several years ago. More powerful clones are now available for about $1000. The learning curve applies here as well as to any other mass-produced product. Open architecture actually facilitates providing a wide range of products without redesign, and can *reduce* costs for manufacturers. As for "flexible and adaptable," the EIA seems to be talking out of both sides of its mouth. On the one hand, they are trashing the OAR in favor of a completely fixed one and then claiming that the latter can be "flexible and adaptable." Flexibility and adaptability are the fundamental reasons for the OAR.

"Open Architecture Raises Safety Concerns" This statement is entirely without basis in fact, and I am puzzled as to why it was made and as to how to respond. Plugging new cards into a motherboard raises fewer electrical safety problems than hooking a VCR to a receiver, and even the latter does not cause any problem. Home computers using a similar structure have not raised any safety concerns. It should also be noted that modules for insertion in home receivers could readily be made more rugged - like video-game modules rather than like boards for personal computers.

"Open Architecture Will Cause Consumer Confusion" It is hard to think of anything more confusing that the marketing of several different kinds of mutually incompatible ATV receivers, a prospect that the OAR is designed to prevent. With properly defined buses, all modules will work in all receivers made according to specifications, just as many manufacturers' cards plug into expansion slots on IBM PC's and their many clones.

"Open Architecture Raises Reliability/Servicing and Quality Issues" It is true that whenever products of different manufacturers are put together, questions may be raised as to which is malfunctioning. In a free market, we put up with this for the sake of greater choice. The situation is no different from using modular audio systems, non-Bell telephones, or for connecting VCR's to receivers. With respect to servicing, bus-oriented designs are much *easier* to service because diagnostic programs can be used, as are now being used in some advanced automobile servicing systems.

"Open Architecture Ignores the Unique Nature of a TV. ...it processes delicate analog signals. High voltage, high frequencies, and spectrum interference considerations are very complex and costly to engineer..." If these sentiments are widespread in the American TV manufacturing community, it may be a partial explanation as to why so many US manufacturers have gone out of the TV business. A television receiver is *not* a unique product. Computer terminals use essentially the same circuitry. As for "delicate analog signals," surely the EIA has heard of the compact-disk digital audio system. All of the interfaces of the OAR, except for rf and baseband inputs, are digital, thus avoiding analog interconnection problems.

It is the conventional wisdom that generals tend to fight each war with the weapons of the last war. One large American TV manufacturer claimed for some time that tubes were better than transistors. Another one claimed that the craftsmanship of hand soldering made better TV's than machine soldering. This is 1988 and the receivers we are talking about will be used in the next century. They ought not to be designed with old and worn-out technology.

"Open Architecture is Rarely Appropriate. An OAR may be appropriate when the technology is still developing and it is premature to set a standard, i.e., all the technology to set a standard for ATV is not available. But even the most ardent supporter of OA, Dr. Schreiber of MIT, recognizes that the technology is available. (See June 1988 SMPTE Journal.)" Like the safety issue, this comment is entirely incorrect. The article referred to, by Prof. Eric Dubois of INRS, Montreal, and myself, dealt with multidimensional filtering for removal of cross effects in NTSC. It is *totally* irrelevant to the issue discussed here, as would be apparent to anyone who read even the abstract.

With respect to whether ATV is still developing or not, the very existence of the large number of proposals to the FCC, most of which were unheard of 12 months ago, is evidence that the field is in a state of very rapid development. Even MUSE, the system that is sometimes claimed to be completely ready for manufacture and use, was shown in numerous modified forms at NAB in April. In view of all this on-going development, it should be clear that any standard promulgated in the very near future is likely to be full of errors.

"Open Architecture is an Excuse for Delay" On the contrary, open architecture is a way to get started quickly on ATV without the hazards associated with premature standard setting. I am far from alone in advising the FCC to go slow in establishing a standard. It is well to bear in mind that nearly everyone commenting on these issues has a financial interest in one outcome or the other. This is perfectly natural and entirely correct, but we would be foolish not to recognize it. Those who think that *their* standard will dominate, or who expect to profit from an early single-standard decision, will naturally support such a decision and find many reasons why preparing to cope with more than one standard is the road to disaster. I rather suspect that if the FCC does make an early decision, many of the losers in this competition will suddenly become advocates of open architecture.

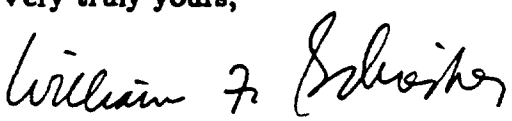
****

Conclusion

The most significant objection to the OAR concerns its cost. I have pointed out that all ATV receivers must cope with at least two standards, and that the structure that best does that can, at little extra cost, cope with many. This structure has many other advantages, not the least of which is very easy interconnection to a wide variety of other services that will surely be developed. I do not advocate delay, and I strongly favor a decision on the terrestrial-broadcasting standards issue as soon as it can be made with confidence. In making this decision, due regard must be given to the requirements of and probable ATV scenarios in alternative media, as well as developments that will surely be made in the over-the-air system as improved components become available and our knowledge of television signal processing improves.

There is no legitimate concern about the OAR encouraging delay in setting standards, about the inability of the OAR to be cost-reduced over time, about safety, about consumer confusion, about the appropriateness of the OAR for the early introduction of ATV service, and about reliability. A TV receiver is *not* a unique product, but an electronic appliance that ought to be made with technology appropriate to its time, and not to that of an earlier age.

Very truly yours,



William F. Schreiber
Professor of Electrical Engineering
Director, Advanced Television Research Program

Encl: "OAR: The Open-Architecture Television Receiver," ATRP-T-88R, 12 June 88
EIA letter

Cc: Commissioner Patricia Diaz Dennis
Commissioner James H. Quello
Acting Secretary H. Walker Feaster
(for inclusion in the public record of Mass Media Docket 87-268)
Alex. D. Felker, Chief, Mass Media Bureau
Dr. Thomay P. Stanley, Chief Engineer
William Hassinger, Engineering Assistant
Richard E. Wiley, Chairman, Advisory Committee on ATV
Member companies of the Center for Advanced Television Studies

DEPARTMENT OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CAMBRIDGE, MASSACHUSETTS 02139

THE OPEN-ARCHITECTURE TELEVISION RECEIVER

The purpose of this brief note is to give a nontechnical description of the concept and to explain why we believe this is an appropriate kind of receiver to use in the Advanced Television Systems being considered for the United States.

All TV receivers consist of a tuner, a signal-processing section, and a display, including audio. In today's receivers, the middle portion accounts for 10-25% of the cost. Most of the cost is in the picture tube and associated hardware. In HDTV receivers, the display, at least initially, will account for the overwhelming portion of the cost. The main innovation of the OAR is to make the signal-processing section digital and programmable. (This is innovative only with respect to TV receivers; it is an increasingly common way to design complicated hardware today.) In addition, we have put as many tuner functions as possible into digital signal processing hardware. The display section does include a fixed upconverter to achieve a progressively scanned display with a high line and frame rate. At present, this is only found in a few high-end receivers, but is likely to be used in all ATV receivers, since it is now well known that this is required to produce the highest quality image from whatever is transmitted.

The use of programmable digital signal processing (DSP) rather than fixed processing (all ATV receivers will use at least some digital processing) raises the cost very little, if at all, and achieves important objectives not otherwise possible. In all likelihood, if a receiver must deal with two or more transmission standards, the OAR is the *cheapest* way to build it, in the time-frame of even the first ATV systems.

1. Such a receiver can be adapted to a range of ATV transmission formats at low cost, without obsolescence, and without set-top converters. It is therefore not necessary to wait until a perfect format is selected before launching an ATV service. All of the currently proposed formats could readily be accomodated in the OAR.

2. Image quality can be improved in an evolutionary manner over the life of the receiver by modifying the operating mode of the receiver or by adding plug-in modules. Any available headroom in the transmission systems can be utilized.

3. Such a receiver can readily be interfaced with VCR's, cable, fiber, DBS, optical disks, computers, video games, cameras, electronic still photographic equipment, interactive systems, people meters, addressing/encryption systems, and other devices not yet imagined. It does not complicate these other systems - it simplifies them since the computing power of the OAR can be used to facilitate the interconnection. No interface boxes are used. Most peripherals plug into one of the receiver busses, just the way computer peripherals plug into computer busses.

4. The open architecture facilitates the provision of software or hardware add-ons by third parties, such as picture-in-picture, image enhancement, freeze-frame, viewer-controlled zoom and pan, home video production systems, etc. Provision can be made for much better viewer control of color and tone reproduction, as is routinely done in graphic

arts. Of course, the original manufacturer can also provide these functions. In fact, this architecture makes it easy for the manufacturer to provide a large range of receivers for different market segments without complete redesign. For the top-end market, the three receivers sections could be offered as separate components.

5. A receiver with substantial processing power makes possible a much more flexible transmission system design. For example, in the MIT-CC system, we utilize a variable transmission frame rate, where we optimize the tradeoff between spatial and temporal resolution according to the subject matter, on a scene-by-scene basis. Eventually this can be done on a point-by-point basis within each frame.

The Input Section

The OAR requires only three input terminals: RF, baseband (3 wires), and digital. RF signals are converted to baseband and baseband signals are digitized and stored in a first step. All further decoding is done in DSP hardware and software, according to the particular transmission system being used.

The Computation Section

This section is, in fact, a signal-processing computer. It makes use of the cheap and powerful chips now being developed for computers. (If such receivers become common, they will be the largest consumers of such chips.) One of the main reasons for going to such a processing structure is to take advantage of the enormous investment being made in the development of such chips for other purposes. An important feature is the well defined busses, which permit designers to develop other devices that plug in very easily. A typical function of this processor is receiving information from the input frame store and then rearranging and interpolating it to the standard rates utilized in the display memory. It does this under supervision of the control module, which is programmed by a small amount of data transmitted along with the signal, or possibly by manual viewer control when using other input sources.

The Display Section

All receivers need not have the same line and frame rate on the display (progressive scan and as high line and frame rates as possible should be used) but all kinds of signals received, including NTSC, would be displayed at the same standard on any one receiver. The display section would include a frame store, (there is absolutely NO advantage for an ATV receiver not to use frame stores) fixed interpolation circuitry, and digital-to-analog converters. If desired, an RGB interface could be provided for foreign signals, but it would be much better to route those signals through the input section so that line- and frame-rate conversion could be done as required. It should be noted that this display is very similar to those used today in many computer graphics systems.

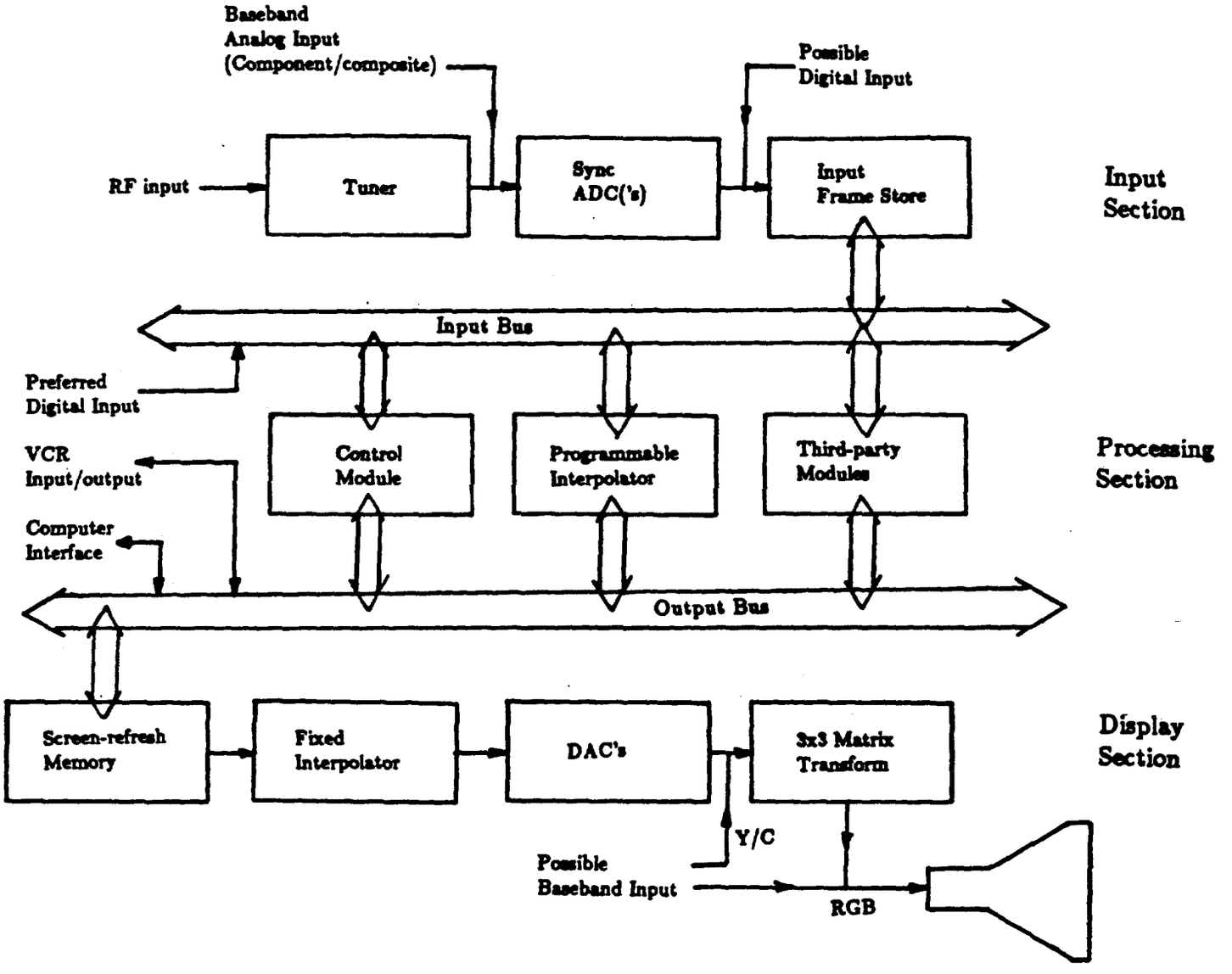
The OAR in a Multiple-Standards Environment

Based on long and extensive practical experience in the design of sophisticated electronic systems for production, it is my opinion that this type of receiver will be the *cheapest* as well as the most convenient way to build high-definition receivers that have to cope with multiple standards. It will be cheapest for the multinational manufacturer and therefore cheapest for the consumer. This results mainly from the fact that the OAR scan-converts all formats to a single display standard. The latter is *mandatory* for highest image quality in any system. Once this price has been paid, the standards conversion, implemented in low-level DSP hardware, involves ony a few special-purpose chips, and costs very little.

I freely agree that if a single worldwide standard could be agreed upon, a single-purpose receiver would be somewhat cheaper. However, this single standard would have to be fixed in all its details throughout its life, and the latter would have to be guaranteed to be 10-20 years in duration. I fail to see how anyone can seriously believe that this will happen.

All ATV receivers will have to cope with at least one of the current standards - NTSC, PAL, or SECAM. There are likely to be several independent HDTV systems used by cable companies, such as HBO and General Instruments. ACTV is being pushed very hard. In addition, it would be a foolish manufacturer who would not also provide for MUSE capability, and probably the European HDMAC system as well. Note that in the OAR, one merely *provides* for the capability, and does not implement it in every receiver sold. For installations that need the capability, the appropriate hardware or software module is plugged into the bus, as in a PC. No set-top converters are used.

All HDTV receivers will be expensive, certainly at the beginning, because of the picture tube, if nothing else. The OAR adds very little cost to these first sets, and ensures, to the extent possible, that both manufacturer and consumer will get maximum benefit from their investment for many years to come.



THE SMART OPEN-ARCHITECTURE RECEIVER. The input and display sections are fixed, while the the processing section, organized like a personal computer, is programmable under the control of a small amount of digital data transmitted along with the signal. This section could be upgraded by adding or exchanging software or hardware modules, some of which could be offered by third parties. In this example, the detector is incorporated into the processing section, rather than implemented in analog hardware in the "front end," in order to facilitate programmable detection of signals with multiple carriers, such as ACTV and the system proposed by North American Philips. Other configurations are possible in the display unit, which probably would use mixed highs or luminance/chrominance representation in the memory, rather than RGB.